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Mario Vaz¹,
Nadine Karaolis²
Alizon Draper*²
Prakash Shetty²

*Alison Draper currently works in the School of Integrated Health, University of Westminster

¹ Division of Nutrition, Department of Physiology, St. John's Medical School, Bangalore 560034, India

² Public Health Nutrition Unit, London School of Hygiene and Tropical Medicine, 49/51 Bedford Square, London, WC1B 3DP, UK

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A compilation of energy costs of physical activities

Mario Vaz^{1,*}, Nadine Karaolis², Alizon Draper² and Prakash Shetty²

¹Division of Nutrition, Department of Physiology, St. John's Medical College, Bangalore 560034, India:

²Public Health Nutrition Unit, London School of Hygiene and Tropical Medicine, 49/51 Bedford Square, London WC1B 3DP, UK

Abstract

Objectives: There were two objectives: first, to review the existing data on energy costs of specified activities in the light of the recommendations made by the Joint Food and Agriculture Organization/World Health Organization/United Nations University (FAO/WHO/UNU) Expert Consultation of 1985. Second, to compile existing data on the energy costs of physical activities for an updated annexure of the current Expert Consultation on Energy and Protein Requirements.

Design: Electronic and manual search of the literature (predominantly English) to obtain published data on the energy costs of physical activities. The majority of the data prior to 1955 were obtained using an earlier compilation of Passmore and Durnin. Energy costs were expressed as physical activity ratio (PAR); the energy cost of the activity divided by either the measured or predicted basal metabolic rate (BMR).

Results: The compilation provides PARs for an expanded range of activities that include general personal activities, transport, domestic chores, occupational activities, sports and other recreational activities for men and women, separately, where available. The present compilation is largely in agreement with the 1985 compilation, for activities that are common to both compilations.

Conclusions: The present compilation has been based on the need to provide data on adults for a wide spectrum of human activity. There are, however, lacunae in the available data for many activities, between genders, across age groups and in various physiological states.

Keywords
Physical activity
Energy expenditure

Background

The 1985 Joint Food and Agriculture Organization/World Health Organization/United Nations University (FAO/WHO/UNU) Expert Consultation on Energy and Protein Requirements drew up a list of gross energy expenditure in specified activities (Annex 5, of the Technical Report Series, 724)¹. Energy expenditure for each activity was expressed in terms of a 'metabolic constant', a multiple of basal metabolic rate (BMR). Separate lists were drawn up for male and female adults, for both developing and developed countries and in various categories of activity.

Aim of the present compilation of energy costs in specified activities

The aim of the present exercise was:

1. To review the existing data on energy costs of specified activities in the light of the recommendations made by the Joint FAO/WHO/UNU Expert Consultation of 1985¹.
2. To compile existing data into an annexure for the present expert consultation on energy and protein requirements.

Methodology used

Both electronic and manual searches were employed in order to obtain published data on the energy costs of physical activities. The vast majority of data before 1955 have been obtained from the compilation of Passmore and Durnin². Most of the subsequent literature has dealt with energy costs of activity under constrained laboratory conditions using treadmill or bicycle ergometry protocols. Another large section of literature has focused on the energy costs of sports, primarily in well-trained and elite athletes. The 1985 Expert Consultation list of the energy costs of specified activities, focused primarily on daily activities of individuals and this has also been the focus of the present compilation.

Studies that were included in the final analysis were required to have:

- Measurements of the energy costs of activities. The vast majority of studies included had measurements using the Douglas bag technique or using the Kofranyi Michaelis instrument. Some studies reported energy expenditure in terms of oxygen consumption.
- Measurements of BMR, or alternatively, have sufficient anthropometric details to allow for the prediction of BMR.

- Data presented in the accompanying tables which for the main part, are the primary sources of the compilation of energy costs, include a variety of information:
 - The source of the data.
 - The characteristics of the subjects.
 - The nature of the activity, with details wherever available.
 - The instrumentation used in the measurements.
 - The duration of measurement, wherever available.
 - The original data of the energy costs of the activities studied.

In addition, the following data have also been computed and added to the data of each study:

- Predicted BMR: for all studies that did not actually measure BMR, BMR was computed using the FAO/WHO/UNU prediction equations of 1985¹. The equations used were those that either had height and weight as predictor variables or weight alone, depending on the availability of the anthropometric data.
- Physical activity ratios (PARs): otherwise referred to as 'metabolic constant' in the 1985 compilation, was computed as the energy cost of the activity divided by either the predicted or measured BMR.
- Energy costs of activities: wherever data was presented in the form of oxygen consumption, this was converted into energy equivalents using a standard 1 litre O₂ = 5 kcal.
- The final collation of the energy costs of specified activities includes the data of the present compilation as well as some data of the 1985 compilation for which data was not reviewed in the present compilation. Where more than one study has contributed to the PAR of a specific activity, a 'PAR range' has been provided. This essentially indicates the highest and lowest reported PAR for a particular activity. This provides the user of the data with some idea of the between-study variability in the estimation of the PAR.

Comparison of the present compilation with the 1985 data

The present compilation is largely in agreement with the 1985 data for activities that are common to both compilations. In some situations, despite the apparently common source of information, calculated PARs differ marginally. This is likely to be due to different methods of computing the BMR. In the final compilation of the data, PARs are reported based on the calculations done during this compilation, even when the differences between the previous and the present compilation appear small. The final decision on which of the PARs to use should take into account the different methods, if any, of arriving at the PAR and of usage of BMR prediction equations. The methods

by which the original PARs in the 1985 compilation were arrived at were unavailable to the authors at the time of this compilation. One PAR that has been retained from the original compilation despite the fact that the actual PAR may be marginally lower is that of sleep, which has been retained as 1.0. This is because of the greater ease with which the total energy cost of sleep can be computed and the marginal effect that changing the PAR would have on the estimate of daily physical activity level (PAL). For some of the activities, the present compilation appears more than marginally different from the 1985 recommendations. This may be due to the addition of more studies in the present compilation and the high variability of PARs across studies.

Limitations of the data

This compilation uses data from many sources and the studies that have been reviewed have varied in their detail and methodology. Stringent selection criteria, would have reduced the available data on PARs considerably. A decision was taken to be inclusive, rather than exclusive, with the aim of providing a wide coverage of activities. Wherever possible, the data were assessed for face validity when more common activities, the PARs of which have been better documented, were described. Nevertheless, the user of the tables should be aware of the issues that need to be taken into consideration while accepting the data. These include:

- Varied descriptions of the activities: while some studies have been explicit in the description of the activities, most have used single word or short phrase descriptors. This poses a problem while collating data on the same activity from multiple sources. In the present compilation, the descriptors used by the investigators have largely been conserved and in situations where the same activity may have been performed differently (using a different posture, for instance), the activity is listed separately with its own PAR. This does not necessarily mean that the two activities have truly different PARs, merely that one descriptor may be more applicable in a local situation than another. For instance, under 'domestic chores', PARs for 'washing clothes' have been listed under several heads: 'washing clothes-squatting on the ground', 'washing clothes-standing', 'washing clothes-sitting', 'washing clothes-unspecified' and 'washing small clothes'. The advantage here for the user is that they can choose which activity is most suitable for their local circumstances, rather than have to make a decision as to whether a generic 'washing clothes' is applicable for them.
- Varied methodology used: some studies have used measurements at 'steady-state', others have used 'point' measurements. The criteria for 'steady-state' measurements also vary between studies. Details about the

calibration of instruments are variable across different studies.

- Computation of the BMR: in the present compilation, computation of BMRs was done using the anthropometry provided. While in all instances the BMR was computed using the FAO/WHO/UNU equations of 1985, anthropometric data was often available only for the entire study group, while the specified activities were measured in subsets of the whole group. This would have contributed to errors in the computation of the BMR for the subset and estimation of the PAR.
- Conditions of measurement are frequently inadequately described. Details like the climatic conditions, the time of day of the measurement, etc. are unavailable for many studies.
- Sample used: some of the present compilation is based on single study, single measurement data, while others have made multiple observations on the chosen subjects. For many of the activities data are not available for both genders.
- It is important to recognise that the PARs presented, represent data related to the actual activity and are not inclusive of the rest periods that may be associated with the normal performance of the activity.
- Inadequate coverage: there are some areas of human activity that are not represented in the final compilation because data was not accessible to the author, or because no data appears to be available. Similarly, non-English data sources have not been reviewed.

Use of the data

In order to determine the actual energy cost of an activity, it is necessary to first determine the BMR, either by actual measurement or by using prediction equations. The energy cost of the activity is then computed by multiplying the BMR of the individual with the PAR reported in the table. When this is multiplied by the duration (in minutes) of the activity, the total energy expenditure related to the activity is obtained. Thus as an example, if an individual who had a BMR of $1.0 \text{ kcal min}^{-1}$, washes clothes while squatting on the ground (PAR = 2.8) for 10 minutes, the total energy expended will be $1.0 \times 2.8 \times 10 = 28 \text{ kcal}$.

There are several important problems that will be faced by people who use the tables.

Does a small difference in PARs between genders imply a significant gender difference in the energy cost of an activity?

It is important to recognise that the PARs presented in the final compilation are actually computed PARs from the studies that have been reviewed. A small difference in the PAR between the genders may thus be of no significance. Differences between the genders in the final compilation

could be attributed to various factors including different sources of data, the number of sources available, and different methods of performing the activity, among others.

PARs are available for only one gender

In the present compilation, 62 activities were identified for which there were matching data for both males and females from the same study, over a wide PAR range. Male and female PARs were highly correlated ($r = 0.97$). Female PARs could be predicted from the male PAR using the equation $0.968 \times \text{Male PAR} + 0.194$. Based on this analysis, it would be reasonable to use the PAR of the available gender for both genders, when data is not available for both males and females.

The PAR for an activity is not listed

Where the PAR for an activity is not listed, it may be necessary to use the PAR of an activity that is closely related or similar in intensity. While this calls for judgement by the user, there appears to be no alternative for this, until such data are generated.

The average PAR for an activity seems too high or too low

This is because the average PAR in the final compilation is an average of the PARs obtained from different studies. The value across studies is quite variable and may, in part, be due to the variable way in which the same activity has been performed in the different studies as well as measurement errors. In such a situation, the PAR range has been provided, which is basically the lowest and highest PAR reported across studies. The range will allow the user to make a decision about which value within the range provided is appropriate for the activity, performed under specific conditions.

What PAR should be applied when an activity has been performed for a long duration with obvious rest periods or pauses?

Since the PARs in the present compilation, like those of the 1985 compilation, reflect values of activities during the actual performance of the activity, application of the PARs for durations when there have been rest periods/pauses will tend to overestimate the energy expenditure. One of the approaches to this problem may be to assign a correction factor that takes into account rest pauses. A case in point, where this has been attempted is James and Schofield³, based on the earlier FAO/WHO/UNU Expert Consultation, where the authors have suggested the use of Integrated Energy Indices (IEI), which are essentially PARs, corrected for pauses/rest periods. According to the

method proposed, PARs can be divided into light, moderate and heavy activities based on PAR cut-offs of 1.0–2.5, 2.6–3.9 and 4.0+. Average estimates of the length of pauses during specified activities is estimated at 75% of the time of light activities, 25% of the time for moderate activities and 40% of the time for heavy activities. The average estimates of PAR for the rest periods/pauses are 1.54 for males and 1.68 for females.

Conclusion

The present compilation has been based on the need to provide data on adults for a wide spectrum of human activity. There are, however, lacunae in the available data for many activities, between genders, across age groups and in various physiological states. Future work needs to target these areas, while addressing the limitations of the available data listed earlier.

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Appendix

A compilation of the details of the individual studies used for the collation of data on energy costs of specified activities

Studies are presented according to alphabetical order of the first author.

Table 1 Almero, 1984. Energy costs of construction workers in the Philippines⁴

Activities	Energy cost of activity (kcal min ⁻¹)		PAR	
	Men	Women	Men	Women
General labour				
Carrying box with load of 8–12 kg	4.902		4.41	
Mix cement using shovel	5.866		5.27	
Tapping-chipping cement walls	3.647		3.28	
Shovel sand	7.89		7.09	
Sift sand using sieve	4.712		4.24	
Carry H-blocks	2.336		2.1	
Acid clean tiles	3.894		3.5	
Carry-transfer wood	7.684		6.91	
Masonry				
Smooth surface of cemented walls	4.940		4.44	
Tapping-chipping tiles	1.804		1.62	
Grouting joints of tiles and blocks	3.902		3.51	
Aligning blocks	5.828		5.24	
Tapping to bore hole on cement walls/floors	4.083		3.67	
Plastering using wood float	3.155		2.84	
Make sandblaster	2.703		2.43	
Sandblast	5.046		4.54	
Steel brush wash out	3.820		3.43	
Carpentry				
Sawing wood	5.596		5.03	
Planing	6.249		5.62	
Form framework (by sawing and hammering)	3.995		3.592	
Form parquet (put in place)	5.793		5.21	
Make cabinet doors and hinges	3.824		3.44	
Drilling wood	5.855		5.26	
Electricals				
Hook up wire for PVC	3.844		3.46	
Tapping-splicing	3.358		3.02	
Painting				
Painting	4.012		3.61	
Varnishing	3.562		3.2	
Sandpaper balustrade	3.180		2.86	

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio.

Subjects: 25 males, age 25 ± 5 years, height 161 ± 6 cm, weight 51 ± 5 kg (all mean ± SD).

Equipment: Max Planck respirometer calibrated according to the method of Durnin. Expired O₂ measured using Beckman E2 analyser.

Measurements: 8 min collections made, 1–2 determinations/activity/subject.

BMR measured in 19 subjects using the Sanborn metabolism apparatus.

PAR calculated using measured BMRs.

Table 2 Bandyopadhyay *et al.*, 1980. Energy cost of some basic activities of college students in India⁵

Activities	Energy cost of activity (kcal min ⁻¹)		PAR	
	Men	Women	Men	Women
Lying resting	0.93		1.07	
Sitting resting, sitting and eating, sitting on trains, buses etc.	1.01		1.16	
Standing resting	1.07		1.23	
Sitting studying	1.11		1.28	
Sitting working; shoe polishing, washing clothes	1.18		1.36	
Standing working; bathing, dressing, shaving etc.	1.43		1.64	
Walking	2.28		2.62	

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio.

Subjects: all male, 9 athletes and 11 non-athletes. Data collation restricted to non-athletes. Age 19 ± 2.4 years, height 167.5 ± 7.4 cm, weight 51.1 ± 6.7 kg, per cent fat 10.1 ± 2.2 (all mean ± SD).

Equipment: Douglas bag, with O₂ estimation from Scholander micrometer.

Measurements: duration of activities not given. BMR for the group 0.87 ± 0.032 kcal min⁻¹.

PAR calculated using measured BMRs.

Table 3 Banerjee *et al.*, 1972. Variety of tasks in Singapore⁶

Activities	Energy cost of activity (kcal min ⁻¹)		PAR	
	Men	Women	Men	Women
Sitting	1.03	0.68	1.06	1.05
Sitting and reading	1.03	0.70	1.06	1.08
Sitting and writing	1.11	0.78	1.14	1.2
Standing	1.39	0.89	1.43	1.37
Walking (on a level ground at 4–4.8 km h ⁻¹)	2.98	2.10	3.07	3.23
Running (on a level ground at 7–9 km h ⁻¹)	6.15	4.55	6.34	7

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio.
 Subjects: Data are presented here only for the sedentary (untrained) subjects – Ten 18–25-year-old male medical students; height 172.5 cm, weight 65.0 kg, Lean body mass 50.4 kg and 10 females; height 157.0 cm, weight 47.5 kg, Lean body mass 36.2 kg (all mean).
 Equipment: Max Planck respirometer with Lloyd's gas analysis apparatus for O₂ and CO₂.
 Measurements: for 5 minutes. With 10 minute breaks between tests.
 PAR calculated using measured BMR (0.97 kcal min⁻¹ for men, 0.65 kcal min⁻¹ for women, mean).

Table 4 Barnes *et al.*, 1973. Energy costs of activities during long haul cabin activities⁷

Activities	Energy cost of activity (kcal min ⁻¹)		PAR	
	Men	Women	Men	Women
Galley work				
First class	3.67	2.89	3.02	3.19
Economy: light meal	3.19	2.5	2.62	2.76
Economy: main meal	4.12	3.24	3.69	3.58
Serving meals				
First class	3.26	2.56	2.68	2.83
Economy trays by hand, light meal	4.2	3.3	3.46	3.64
Economy: trays by hand, main meal	3.78	2.97	3.11	3.28
Mixed mobile tray box	3.86	3.03	3.18	3.34
Bar service				
Dispensing	4.11	3.23	3.38	3.57
Serving	2.67	2.1	2.2	2.32
Standard walking (3 m h ⁻¹)	4.12	3.56	3.39	3.93

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio.
 Subjects: characteristics not described. Energy costs for a 70 kg man and 55 kg woman.
 Equipment: Max Planck respirometer with Lloyd Haldane gas analyser.
 Measurements: for 10 minutes. Details of gas collection and calibration not given.
 BMR not measured. PAR based on predicted BMR assuming an age range of 18–30 years.

Table 5 Bleiberg *et al.*, 1980. Energy expenditure of various farming activities in female Upper-Volta farmers⁸

Activities	n	Energy cost of activity (kcal min ⁻¹)		PAR	
		Men	Women	Men	Women
Lying	29		1.24		1.37
Sitting	27		1.29		1.42
Standing	27		1.35		1.49
Walking	18		3.0		3.31
Sowing	4		3.9		4.31
Thinning out and replanting	5		3.6		3.97
Hoeing	11		4.3		4.75
Grinding grain on a millstone	24		4.2		4.64
Pounding	32		4.5		4.97
Fetching water from a well	21		4.1		4.53
Fetching water from the swamp	2		3.9		4.31
Washing clothes	3		3.2		3.53
Stirring sorghum or millet porridge	7		3.7		4.09

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio.
 Subjects: numbers variable for each activity. Age 30.6 years, height 157 cm, weight 50.6 kg, per cent fat 19.3 (all means).
 Equipment: Kofranyi–Michaelis respirometer. Expired air analysed within 5 minutes of collection with Servomex O₂ analyser.
 Measurement: for approx 10 minutes for each activity. Energy costs were recalculated for a standard wt of 55 kg.
 PAR calculated using BMR predicted for a body wt of 55 kg.

Table 6 Brun, 1979. Energy cost of Iranian agricultural workers across four seasons⁹

Activities	Energy cost of activity (kcal h ⁻¹ min ⁻¹)		PAR	
	Men	Women	Men	Women
Cotton harvest				
Picking cotton and carrying sack	3.6		3.21	
Loading, collecting sacks on lorry	7.1		6.34	
Irrigation				
Opening and closing irrigation channels	4.5		4.01	
Digging activities				
Channel digging	7.0		6.25	
Digging	6.4		5.71	
Cultivation				
Weeding	5.2		4.64	
Tending melons				
Grain harvest				
Tending threshing machine	3.8		3.39	
Lifting grain sacks (weighing and loading)	4.0		3.57	
Winnowing	4.0		3.57	
Animals				
Tending animals	5.1		4.55	
Collecting and spreading manure	5.5		4.91	
Loading manure	6.8		6.07	
Transport				
Riding donkey/tractor	2.9		2.59	
Cycling on level dirt road	5.6		5.0	
Railway work				
Raking gravel	4.7		4.2	
Using pick under the rails	7.7		6.87	
Roof repair				
Shovelling and carrying mud	5.9		5.27	
Spreading mud on roof	2.9		2.59	

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio.

Subjects: 45 males, age ?, mean 35–39 years, mean weight across seasons 56–59 kg.

Equipment: Max Planck respirometer with a Pauling O₂ analyser.

Measurements: most activities measured for 10–15 min. No BMR.

PAR calculated using predicted BMR (age range 30–60 years and an avg wt of 57.5 kg) and based on recomputed energy costs expressed in kcal min⁻¹.

Table 7 Brun, 1981. Energy cost of a variety of agricultural activities in Upper-Volta farmers¹⁰

Activities	n	Energy cost of activity (kcal min ⁻¹)		PAR	
		Men	Women	Men	Women
Lying	31	1.39		1.25	
Sitting	33	1.38		1.24	
Standing	29	1.44		1.29	
Walking	25	3.6		3.23	
Walking slowly	4	2.9		2.6	
Walking fast	2	4.2		3.77	
Cycling	12	4.4		3.94	
Sowing	5	3.9		3.5	
Thinning out and replanting	8	3.8		3.41	
Hoeing	11	5.1		4.57	
Land clearing	2	6.9		6.19	
Sorghum harvest: standing, cutting the ears with knife or hand	6	2.4		2.15	
Bent forward, uprooting potatoes with a hoe	5	3.9		3.5	
Plucking leaves and stems, standing	1	6.8		6.1	
Kneeling and sorting, sweet potatoes	1	1.8		1.61	
Cutting straw with a sickle, bent forward	3	5.6		5.02	
Walking with a sheaf of straw on head (11.5 kg)	1	3.4		3.05	
Pulling and breaking into pieces branches from dead trees, walking and bending forward	2	3.8		3.41	
Cutting wood with a machete	1	4.6		4.12	
Unloading a cart of branches	2	3.6		3.23	
Vine weaving	2	2.4		2.15	
Hand weaving sitting on the ground	2	2.6		2.33	
Hand sewing	1	1.8		1.61	
Sewing with treadle sewing machine	3	2.4		2.15	
Clay kneading	1	3.0		2.69	
Sawing a calabash by hand, bending forward	1	3.1		2.78	
Making mud bricks squatting	3	3.3		2.96	
Standing, making a mud wall	1	1.8		1.61	
Digging the earth with a pick-axe to make mud	2	6.4		5.74	
Shovelling the mud	2	4.9		4.39	
Copying verses of the Koran, sitting	1	1.2		1.08	

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio.
 Subjects: all males. Number per activity is variable. Age 32.2 year, height 170 cm, weight 58.5 kg, fat 10.3 (all means).
 Equipment: Kofranyi–Michaelis respirometer, expired air analysed with a Servomex O₂ analyser.
 Measurements: no BMR, all energy costs expressed for a standard weight of 60 kg.
 PAR based on predicted BMR assuming a wt of 60 kg.

Table 8 Brun, 1992. Not a primary source but reviews data of the author of agricultural activities of Chinese female farmers from Hainan¹¹

Activities	n	Energy cost of activity (kcal min ⁻¹)		PAR	
		Men	Women	Men	Women
Sitting inactive	11		1.08		1.32
Standing resting	4		1.43		1.74
Squatting washing clothes	4		2.09		2.55
Standing hoeing	3		3.82		4.66
Bending, planting potatoes	7		3.39		4.13
Bending harvesting potatoes	8		2.36		2.88
Ploughing with buffalo	4		2.94		3.59
Standing sowing rice	10		2.15		2.62
Bending, transplanting rice	31		2.84		3.46
Bending, cutting rice	26		3.22		3.93
Squatting, bundling rice	6		2.42		2.95
Standing, threshing rice	8		3.97		4.84
Walking, carrying 30–35 kg	5		3.75		4.57
Walking, tapping rubber	5		2.52		3.07

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio.
 Subjects: all women, age ?, average body weight = 47 kg, numbers variable for each activity.
 Measurements: for each activity, one or several measurements using Douglas bags or portable spirometers.
 PAR calculated using predicted BMR for 18–30 years and a wt of 47 kg.

Table 9 Cassady, 1992. Energy cost of calisthenics performed on land and in water¹²

Activities	Energy cost of activity (VO ₂ in l min ⁻¹)		PAR	
	Men	Women	Men	Women
Land, upper extremity 20 rep min ⁻¹	0.660	0.481	2.84	2.65
Land, lower extremity 20 rep min ⁻¹	1.183	0.905	5.09	4.99
Water, upper extremity 20 rep min ⁻¹	1.092	0.655	4.7	3.61
Water, lower extremity 20 rep min ⁻¹	1.547	1.078	6.66	5.95

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio.

Subjects: 40 healthy subjects (20 men and 20 women), mean age 25 years, mean wt 69.6 kg.

Equipment: open-circuit system. Mouthpiece to Collins gasometer, with Beckman's O₂ and CO₂ analysers.

Measurements: O₂ measurements were made in the final 30 seconds of each exercise stage (3 minutes). For the water exercises, the subject performed the exercises in a Hubbard tank with water adjusted to shoulder level for each subject. No BMR.

Energy costs are recalculated from the MET (3.5 ml kg⁻¹ min⁻¹) and expressed for a standard 65 kg male and a 55 kg female.

PAR calculated using predicted BMR.

Table 10 Cole, 1987. Variety of basic activities carried out by Nigerian University students¹³

Activities	n	Energy cost of activity (kcal min ⁻¹)		PAR	
		Men	Women	Men	Women
Sitting	10	1.74		1.18	
Walking at normal pace	12	4.21		2.86	
Personal domestic necessities	7	3.61		2.46	
Polishing shoes, washing clothes, cleaning the room, fetching water etc.					
Climbing stairs	5	7.29		4.95	
Lying down in bed awake	6	1.49		1.01	
Standing	7	3.61		2.46	

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio.

Subjects: 20 males, numbers different for different activities. Age 24 years, height 171 cm, weight 61.1 kg (all mean).

Equipment: Max Planck respiration-gasometer.

Measurement: for 10–15 minutes for each activity.

PAR based on predicted BMR.

Table 11 Costa, 1989. Apple farming activities in Italy¹⁴

Activities	Energy cost of activity (kcal min ⁻¹)		PAR	
	Men	Women	Men	Women
Pruning: done by hand with scissors (300 g) and saw (500 g) standing on the ground or on a wooden ladder against a tree	4.59		3.6	
Weeding: cutting and bundling fallen branches using a hatchet (1900 g), bill-hook (700 g), rake (1000 g) and hay-fork (1600 g)	6.02		4.73	
Hand spray: of pesticides – hauling a spear (1000 g) connected to a tank through a flexible rubber tube	4.85		3.81	
Mech spray: of pesticides – driving a tractor slowly (2–3 km h ⁻¹) among the trees towing a tank provided with an atomiser	2.37		1.86	
Mowing: cutting the grass among the trees while walking and directing a self-propelled motor mowing machine (100 kg, 9 hp)	6.25		4.91	
Picking: handling a basket in one hand and picking with the other, standing on the ground or on a ladder. The full basket can reach a weight of 12 kg	4.58		3.6	

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio.

Subjects: 17 males. Age 40.1 years, height 175.4, weight 80.1 kg (all means).

Measurement: VO₂ measured for short periods (5–10 minutes) by Oxylog in steady state conditions (<2.5% incr).

PAR calculated using the predicted BMR.

Table 12 Das, 1966. Energy cost of different types of load carrying in Indians¹⁵

Activities	Energy cost of activity (kcal min ⁻¹)		PAR	
	Men	Women	Men	Women
Carrying load with shoulder straps				
0 gradient	2.51		2.27	
10% gradient	5.6		5.05	
20% gradient	8.5		7.67	
Carrying load with forehead strap				
0 gradient	2.61		2.43	
10% gradient	6.1		5.5	
20% gradient	8.9		8.03	
Carrying load on head				
0 gradient	2.61		2.36	
10% gradient	7.4		6.68	
20% gradient	10.3		9.29	

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio. Subjects: six healthy load carriers from the hills. Age 24 years, height 167.8 cm, weight 60 kg. Equipment: Max Planck respirometer with gas analysis on a Scholander's gas analyser. Measurements: for 5 minutes with gas collections in the last 2 minutes. Load was standard at 27 kg. Speed of treadmill was 3.22 km h⁻¹. PAR calculated using predicted BMR for the group.

Table 13 Datta, 1978. The energy cost of rickshaw pulling by Indian males with different loads¹⁶

Activities	n	Energy cost of activity (kcal min ⁻¹)		PAR	
		Men	Women	Men	Women
Rest	9	1.26			
Pulling rickshaw with no load	10	5.39		4.03	
Pulling rickshaw with 1 man (50 + 80 kg)	10	7.16		5.34	
Pulling rickshaw with 2 men (100 + 80 kg)	10	8.92		6.66	
Pulling rickshaw with 2 men and 50 kg load (100 + 80 + 50)	10	11.57		8.64	

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio. Subjects: n = 10. Age 33.8 years, height 162.1 cm, weight 47.8 kg (all means). Equipment: Douglas bag with Haldane gas analyser. Measurement: each activity for 10 minutes. Gas collection from 8 minutes to 10 minutes. PAR calculated using the predicted BMR of the group.

Table 14 Datta, 1983. Energy cost of pulling handcarts in India¹⁷

Activities	Energy cost of activity (kcal min ⁻¹)		PAR	
	Men	Women	Men	Women
Rest (10 am 3–4 hours after morning meal)	1.45		1.1	
No load (190 kg)	6.34		4.82	
+ 185 kg load	9.23		7.01	
+ 370 kg load	12.7		9.64	

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio. Subjects: 10 male handcart-pullers. Age 29.6 years, height 165 cm, weight 50 kg (all means). Equipment: expired air collected in a Douglas bag and analysed using a Haldane gas analyser. Measurements: all done at a constant speed of 5 km h⁻¹. PAR calculated from the predicted BMR.

Table 15 Davies, 1976. Energy cost of cutting sugar cane in Sudanese¹⁸

Activities	Energy cost of activity (kcal min ⁻¹)		PAR	
	Men	Women	Men	Women
Cutting cane (rate was 15.18 kg min ⁻¹)	10.96		7.92	

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio. Subjects: 42 male cane cutters. Age 26.3 years, height 173.2 cm, weight 54.8 kg (all means). Kofranyi–Michaelis respirometer over 20 min. O₂ content with a paramagnetic O₂ analyser – Servomex. PAR calculated based on predicted BMR.

Table 16 de Guzman, 1974. Energy costs of 'Jeepney drivers' in the Philippines¹⁹

Activities	Energy cost of activity (kcal kg ⁻¹ min ⁻¹)		PAR Men
	Men	Women	
Driving	0.046		2.35
Adjust tyres (sitting)	0.033		1.69
Wipe or clean jeep	0.038		1.94
Jack up Jeep	0.067		3.42
Wash Jeep	0.41		2.09

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio. Subjects: 10 males, age 32 years, height 162.2 cm, weight 54.8 kg (all means). Equipment: Max Planck respirometer. Gas analysis with E2 Beckman O₂ analyser. Measurements: Basic activities were measured for 10 minutes, others for 8 minutes; 2–3 determinations of an activity were made on each individual. PAR calculated on the predicted BMR.

Table 17 de Guzman, 1974. Energy cost of activities in Filipino shoemakers and housewives²⁰

Activities	Energy cost of activity (kcal kg ⁻¹ min ⁻¹)		PAR	
	Men	Women	Men	Women
Shoemaker				
Moulding top portion of shoes	0.054		2.85	
Attaching sole	0.054		2.85	
Trimming sole and heel	0.63		3.33	
Uppermaking (prep of top portion of shoes)	0.037		2.22	
Housewife				
Bathing child (standing)		0.058		3.48
Carrying child (standing)		0.032		1.92
Washing clothes		0.044		2.64
Cooking		0.036		2.16

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio. Subjects: eight shoemakers (? male) and 10 housewives (age 34 years, height 155 cm, weight 54 kg, all means). Equipment: Max Planck respirometer. O₂ analysed using Beckman E2 analyser. Measurements: for each activity for 8 minutes. PAR calculated using the predicted BMR.

Table 18 de Guzman, 1978. Energy cost of Filipino clerk-typists²¹

Activities	n	Energy cost of activity (kcal kg ⁻¹ min ⁻¹)		PAR	
		Men	Women	Men	Women
Sitting		0.026		1.31	
Standing		0.029		1.46	
Walking		0.056		2.8	
Sitting activities					
Typing	10	0.035		1.76	
Writing	4	0.028		1.4	
Calculating – desk type electronic calculator	2	0.032		1.61	
Stamping	1	0.023		1.15	
Segregating reports	1	0.023		1.15	
Filing	2	0.026		1.3	
Sorting	2	0.023		1.15	
Proof reading	1	0.023		1.15	
Checking files	1	0.028		1.4	
Checking purchase orders	1	0.028		1.4	
Stapling papers	1	0.028		1.4	
Post-checking	1	0.033		1.66	
Reading	9	0.026		1.3	
Sitting			0.026		1.39
Standing			0.027		1.43
Walking			0.055		2.88
Sitting activities					
Typing	10		0.035		1.84
Writing	9		0.028		1.47
Filing	6		0.028		1.47
Reading	9		0.028		1.47
Tape recording	1		0.027		1.42
Recording transactions (handwriting)	2		0.026		1.36
Counting supplies in the stock room, no lifting involved	1		0.029		1.52
Classifying papers	1		0.025		1.31
Controlling vouchers			0.025		1.31
Phoning	1		0.027		1.27
Thermopherring	1		0.031		1.63

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio.

Subjects: 10 males (age 27.6 years, height 165.4 cm, weight 53.9 kg) 10 women (age 24.7 years, height 154.8 cm, weight 46.9 kg, all means) Filipino men and women.

Equipment: energy cost using Max Planck respirometer and E2 Beckman analyser.

Measurements: each activity for 8–10 minutes, 2–3 determinations done per individual.

BMR for each subject on 2 consecutive days using the Sanborn Basal Metabolator – PAR calculated using measured BMR.

Table 19 de Guzman, 1979. Male and female Filipino textile workers²²

Activities	Energy cost of activity (kcal kg ⁻¹ min ⁻¹)		PAR	
	Men	Women	Men	Women
Sitting	0.022		1.18	
Standing	0.024		1.26	
Walking	0.059		3.11	
Spinning operations				
(Operator tends to spinning frames, creels in new roving bobbins during runouts, pieces-up ends of broken yarns and cleans the machine)				
Ringframe spinning	0.047		2.45	
Delivering and collecting bobbins and boxes (Carriers push loads of boxes of bobbins and deliver them to the spinners. They also collect used bobbins for cleaning)	0.095		4.94	
Pinwinding (Operator rewinds yarns into bobbins used in the weaving shuttles)	0.060		3.12	
Conewinding (Operator feeds bobbins into the machine to spin yarns or threads around big paper cones)	0.065		3.38	
Weaving operations				
Warping (Sufficient number of parallel threads are drawn-out from several cones on creeling stands and rolled into warp beams)	0.059		3.07	
Loading of warp beam (Warp beams are loaded into the creeling machine by means of chains and pulleys)	0.107		5.57	
Counting yarns per dent (The threads are sized and counted in preparation for reaching-in)	0.044		2.29	
Creeling	0.063		3.28	
Weaving (Includes manual movements of cleaning the looms, attaching the loom beams, feeding bobbins into shuttles, and shuttles into looms, stopping the machine and piecing up broken ends or changing empty bobbins)	0.065		3.38	
Cloth cutting (Finished and filled up loom beams are severed and collected by the cloth cutter)	0.076		3.96	
Writing (sitting activity) (Production volume is recorded)	0.024		1.25	
Finishing operations				
Washing-padding (The fabric or woven cloth is brought to the finishing section where it is washed and de-sized, bleached and printed)	0.044		2.29	
Releasing and dye mixing	0.048		2.5	
Gig dyeing	0.049		2.55	
Backtending or high-curing	0.031		1.61	
Cloth inspecting	0.024		1.25	
Sitting		0.024		1.35
Standing		0.024		1.35
Walking		0.053		2.95
Spinning operations				
Ringframe spinning		0.040		2.24
Conewinding		0.040		2.24
Weaving operations				
Warping		0.030		1.68
Denting (standing reaching-in)		0.050		2.8
Reaching-in (sitting)		0.030		1.68
Weaving		0.040		2.24

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio.

Subjects: Males = 25 (age 24.9 years, height 166 cm, weight 54.8 kg), Females = 14 (age 33.1 years, height 153.7 cm, weight 48.7 kg, all means). Variable numbers for different activities.

Equipment: Max Planck respirometer.

Measurements: 10 minutes recording for sitting, standing and walking at own pace; 8 minutes for others; 2–3 determinations per activity per person.

PAR determined using predicted BMR.

Table 20 de Guzman, 1984. Agricultural activities of Filipino Laguna rice farmers²³

Activities	<i>n</i>	Energy cost of activity (kcal kg ⁻¹ min ⁻¹)		PAR	
		Men	Women	Men	Women
Sitting	9	0.027		1.4	
Standing	9	0.027		1.42	
Walking	9	0.061		3.17	
Weeding by hand	9	0.075		3.91	
Mechanical weeding	4	0.123		6.41	
Pushing hand tractor	9	0.119		6.2	
Harvesting	8	0.080		4.17	
Threshing	7	0.115		5.99	
Winnowing	7	0.044		2.29	
Plowing	9	0.126		6.56	
Harrowing	9	0.126		6.56	
Spray	4	0.099		5.16	
Measuring harvested 'palay'	2	0.127		6.61	
Germinating 'palay'	2	0.083		4.32	
Carrying and stacking 'palay'	2	0.100		5.2	
Application of fertiliser	2	0.060		3.13	
Planting	1	0.076		3.96	
Mowing with a scythe	8	0.085		4.43	
Carry 'palay'	2	0.100		5.21	
Sitting	9		0.027		1.46
Standing	9		0.029		1.59
Walking	9		0.050		2.79
Weeding	9		0.081		4.43
Harvesting	9		0.080		4.38
Threshing	7		0.098		5.36
Winnowing	8		0.053		2.9
Planting	9		0.085		4.65

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio.

Subjects: 10 men (age 27 years, height 159 cm, weight 55 kg) 10 women (age 38 years, height 148 cm, weight 47 kg, all means). Variable numbers for different activities.

Equipment: Kofranyi Michaelis respirometer – O₂ measured using Beckman analyser.

Measurements: for 8–10 minutes, 2 determinations per person.

PAR calculated using predicted BMR.

Table 21 di Prampero, 1974. Swimming overhead crawl in a 60 m circum. Annular pool²⁴

Activities	Energy cost of activity (kcal min ⁻¹)		PAR	
	Men	Women	Men	Women
Overhead crawl at a velocity of 0.55 m s ⁻¹	11.0		8.45	

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio.

Subjects: 10 well-trained male college students, height 175.4 cm, weight 78.2 kg.

Measurements: collection from 4 minutes to 6 minutes of exercise in Douglas Bags. O₂ and CO₂ analysed by paramagnetic and infrared methods.

PAR calculated using predicted BMR.

Table 22 Dufour, 1984. Energy costs of mainly horticultural activities of indigenous women in the Amazon²⁵

Activities	n	Energy cost of activity (kcal min ⁻¹)		PAR	
		Men	Women	Men	Women
Sitting quietly	10	1.05		1.2	
Planting manioc	6	3.18		3.64	
Simply pushing vegetative stocks into the ground i.e. slow walking and stooping					
Harvesting manioc	8	2.48		2.83	
3 tasks: destalking, light weeding, pulling up tubers					
Grating manioc	8	3.35		3.83	
Sitting on a low stool: with grating board held horizontal and both hands working					
Sieving manioc	10	3.73		4.26	
Standing: washing and pressing the grated manioc through a circular basket supported by a tripod.					
Walking					
Walking 3 km h ⁻¹	9	2.24		2.56	
Walking was done on a trail near the village, in the relative cool of the morning. The trail was level and generally under canopy cover. Pace was maintained by the investigator using a stop watch to time 50 m segments of the trail. Loads were carried using a basket and trumpline. The habitual walking pace of most women was about 4 km h ⁻¹					
Walking 4 km h ⁻¹	8	2.82		3.22	
Walking 5 km h ⁻¹	8	3.51		4.01	
Walking at 4 km h ⁻¹ and carrying loads					
Carrying 15 kg	8	2.97		3.39	
Carrying 20 kg	9	3.09		3.53	
Carrying 25 kg	9	3.29		3.76	
Carrying 30 kg	9	3.55		4.06	

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio.
 Subjects: Tukanoan Indians, n = 11, Most non-pregnant and non-lactating (age 34 years, height 147.3 cm, weight 49.6 kg, per cent fat 27, all means).
 Equipment: Kofranyi–Michaelis respirometer. Gas analysis with a Lloyd-Haldane gas analyser.
 Measurements: collections for 5–10 minutes following a 5–10 minute warm-up period. Variable number of subjects for different activities.
 PAR calculated using predicted BMR.

Table 23 Edholm, 1955. Activities of army cadets²⁶

Activities	n	Energy cost of activity (kcal min ⁻¹)		PAR	
		Men	Women	Men	Women
Lying	12	1.48		1.21	
Sitting	12	1.60		1.31	
Standing	12	1.82		1.49	
Marching (3–4 m h ⁻¹)	11	6.03		4.94	
Running (at the double in uniform)	9	11.67		9.59	
Stair-climbing (up and down 46 steps 7 inches high)	3	10.3		8.8	
Dressing	9	4.0		3.3	
Ironing (standing 51/2 lb iron)	5	4.2		3.51	
Polishing kit (sitting)	7	2.4		1.96	
Rifle cleaning	6	2.7		2.27	
Archery	2	5.24		4.36	
Batting (running twice between wickets every 6 balls)	6	8.0		6.35	
Bowling	4	8.0		6.35	
Squash	6	10.18		8.52	
Tennis	7	7.13		5.8	
Cycling (12–13 m h ⁻¹)	8	7.72		6.34	
Motor cycling (heavy army)	3	2.82		2.39	
Driving (army truck)	3	3.38		2.87	
Obstacle course	6	6.16		4.94	
Parade	11	5.20		4.26	
Weapon training	12	2.21		1.81	

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio.
 Subjects: 12 British males (age 20 years, height 178 cm, weight 68 kg, all means).
 Equipment: Douglas Bag/Max Planck Institute calorimeter with gas analysis.
 PAR calculated from predicted BMR.

Table 24 Edholm, 1973. Predominantly agricultural activities of Yemenite and Kurdisk Jews in Israel²⁷

Activities	Energy cost of activity (kcal min ⁻¹)		PAR	
	Men	Women	Men	Women
Tractor driving	2.2		1.9	
Truck driving	1.9		1.64	
Horse cart driving (standing)	2.1		1.81	
Potato picking	6.58		5.67	
Potato, filling sacks	3.4		2.93	
Potato, loading sacks on truck	9.3		8.01	
Potato grading	3.15		2.71	
Orange picking	3.7		3.19	
Weeding	3.0		2.58	
Picking carrots	2.6		2.24	
Seed casting	4.5		3.88	
Spray insecticide	5.0		4.31	
Manure spreading	6.3		5.43	
Prune vines	4.05		3.49	
Scythe grass	5.9		5.08	
Fork grass	6.0		5.17	
Sitting	1.32		1.14	
Walking	4.0		3.45	
Walking in mud	8.0		6.89	
Repair work with tractors	4.5		3.88	
Bicycling	7.6		6.55	
Housework				
Wash and tidy		2.5		2.75
Cook		2.0		2.2
Scrub floor		3.2		3.52
Animal work				
Feed cows		3.4		3.74
Feed chicken		3.1		3.41
Field work				
Weeding		3.32		3.66
Top carrots		2.14		2.36
Fork grass		4.5		4.96
Sitting		1.36		1.5
Walking and shopping		4.15		4.57

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio. Subjects: numbers on whom energy costs were measured are not clear, ages between 20 and 30 years.

Equipment: mouth and noseclip with Max Planck respirometer or the Wright flowmeter. Gas analysis with Lloyd-Haldane apparatus.

Measurements: durations unclear.

PAR calculated using predicted BMR assuming a height of 1.72 m and weight of 65 kg for males and 1.62 m and 55 kg for females.

Table 25 Edmundson, 1989. Domestic and occupational activities in rural India²⁸

Activities	n	Energy cost of activity (kcal kg ⁻¹ min ⁻¹)		PAR	
		Men	Women	Men	Women
Sitting	24	0.026		1.23	
Squatting	6	0.027		1.27	
Standing	20	0.030		1.42	
Strolling	5	0.043		2.03	
Walking	16	0.054		2.55	
Light work	8	0.044			
Light carry	4	0.092		4.34	
Heavy carry	7	0.119		5.62	
Ploughing	2	0.130		6.14	
Medium work	10	0.063			
Hoing	6	0.076		3.59	
Heavy work	6	0.110			
Cooking	6		0.040		2.08
Housework	4		0.058		3.01

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio. Subjects: Eight male (age 33.2 years, height 161.1 cm, weight 48.3 kg, per cent fat 17.0) and Eight females (age 28.1 years, height 148.8 cm, weight 36.9 kg, percent fat 21.2, all means). Variable numbers for different activities.

Equipment: Kofranyi-Michaelis respirometer, with gas analysis using Micro-Scholander.

PAR calculated using predicted BMR.

Table 26 Fariduddin, 1975. Energy costs of Bangladeshi rickshaw-pullers and cart-pullers²⁹

Activities	Energy cost of activity (kcal min ⁻¹)		PAR	
	Men	Women	Men	Women
Peddalling rickshaws				
Without passengers	6.66		6.64	
With passengers	7.84		7.82	
Cart pulling				
Without load	5.5		5.68	
With load	6.08		6.28	

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio. Subjects: 10 rickshaw-pullers (age 26 years, height 5.26 ft, weight 50 kg) and 11 cart-pullers (age 25 years, height 5.5 ft, weight 46.8 kg, all means).

Equipment: Douglas bag. Dry gas meter calibration against Tissot's. Lloyd's modification of the Haldane apparatus for O₂ and CO₂.

PAR calculated using predicted BMR.

Table 27 Fariduddin, 1976. Energy cost of some common activities in Bangladesh³⁰

Activities	Energy cost of activity (kcal min ⁻¹)		PAR	
	Men	Women	Men	Women
10 cultivators: ploughing	5.45		5.17	
12 carpenters: wood planning	4.24		4.41	
6 labourers: Earth-cutting in a brick field	5.19		5.52	
6 labourers: brick-breaking	3.4		3.51	

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio.

Subjects: ? male divided into four groups; 10 cultivators (age 29.7 years, height 169.8 cm, weight 54.9 kg), 12 carpenters (age 28.6 years, height 159.3 cm, weight 46.1 kg), six labourers (age 25.5 years, height 163.7 cm, weight 44.3 kg) and six labourers for brick-breaking (age 25 years, height 164 cm, weight 46.8 kg, all means).

Equipment: Douglas bag. Calibrated dry gas meter and Lloyd's modification of Haldane's gas analysis. Expired air collected at the height of activity.

PAR calculated using predicted BMR.

Table 28 Garby, 1987. Energy expenditure during sleep³¹

Activities	Energy cost of activity (kcal min ⁻¹)		PAR	
	Men	Women	Men	Women
Sleep			0.97	0.94

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio. Subjects: 59 subjects (38 male, 21 female). Males (age 24 years, weight 66.6 kg, per cent fat 12.4), Females (age 26 years, weight 64.2 kg, per cent fat 27.7, all means). Equipment: previously validated whole body direct calorimeter. BMR measured as (Watt h⁻¹) males 85.6/1.3 SE, females 71.2/1.09 SE. Measurement: sleeping metabolic rate measured between 11:30 and 6:30 (7 h), subjects went to sleep at 11:00. PAR as computed by the authors.

Table 29 Haisman, 1972. Energy cost of pushing a variety of loaded (50 kg) hand carts during a 30 minute walk³²

Activities	Energy cost of activity (Watt)		PAR	
	Men	Women	Men	Women
Mail cart	478		5.22	
Large garden cart	493		5.42	
Small garden cart	524		5.76	
Golf cart	551		6.06	

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio. Subjects: 7 healthy soldiers (age 20.7 years, height 178.6 cm, weight 78.5 kg, all means). Equipment: Max Planck respirometer. Gas analysis using Beckman E2 O₂ analyser and LB1 CO₂ analyser. Measurement: data here is restricted to values obtained on an outdoor circuit. Data were also collected on a treadmill. PAR calculated using predicted BMR.

Table 30 Igbanugo, 1978. Energy cost of aerobic dancing³³

Activities	Energy cost of activity (kcal min ⁻¹)		PAR	
	Men	Women	Men	Women
Low intensity aerobics	4.07	4.04	3.68	4.45
	4.26	3.87	3.33	4.03
Medium intensity aerobics	6.58	5.83	5.94	6.42
	7.15	6.74	5.58	7.03
High intensity aerobics	9.2	7.73	8.31	8.54
	9.67	7.74	7.55	8.07

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio. Subjects: Two men and two women, non-dancers. Individual anthropometry provided. Equipment: Max Planck respirometer with gas analysers: Beckman for O₂ and Harvard apparatus for CO₂. Measurement: three levels of aerobic dancing; seven routines at each intensity. Each routine 2–3 minutes alternated with recovery periods of 15–90 seconds. Metabolic values include both dance and recovery. PAR calculations based on predicted BMR.

Table 31 Jette, 1979. Energy costs of rope skipping³⁴

Activities	Energy cost of activity (kcal h kg ⁻¹)		PAR
	Men	Women	Men
66 TPM, 2 ft skip, rhythm bounce	9.13		8.68
102 TPM, 2 ft skip, plain bounce	12.39		11.78

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio. TPM – turns per minute. Subjects: Five Canadian males, well conditioned but with minimal experience with rope skipping (age 26.6 years, height 172.5 cm, weight 68.1 kg, all means). Equipment: Tissot gasometer, Godart–Statham paramagnetic O₂ analyser and a G–S CO₂ analyser. Measurement: rope skipping at different levels of intensity: 6–132 turns per minute, each skipping bout: 5 minutes. Expired air collected for 30 second in 3rd and 5th minute. PAR calculated based on the predicted BMR.

Table 32 Lawrence, 1985. Energy cost of a variety of common daily activities³⁵

Activities	n	Energy cost of activity (kcal min ⁻¹)		PAR	
		Men	Women	Men	Women
Shelling ground nuts	37	1.38		1.59	
Plaiting hair	21	1.52		1.75	
Sorting groundnuts	13	1.62		1.87	
Weeding rice	45	1.98		2.28	
Harvesting rice	19	2.04		2.35	
Weeding groundnuts	25	2.81		3.24	
Drawing water	89	2.91		3.36	
Beating groundnuts	15	3.06		3.53	
Washing clothes	29	3.26		3.76	
Bending digging	21	4.05		4.67	
Harvesting groundnuts	17	4.07		4.69	
Standing digging	14	4.72		5.44	
Pounding grain	54	5.02		5.79	

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio. Subjects: women, variable numbers for different activities (age: most from 18 to 35 years). Women consisted of non-pregnant, non-lactating women (average weight 49.8 kg), Pregnant women in the first trimester (average weight 50.4 kg) and lactating mothers (average weight 53.3 kg). Measurement: made using Douglas bags. Gas collections for 5 minutes after a 3 minute equilibrium period. Gas analysis with calibrated analysers. Volume with a wet gas meter. PAR calculated using predicted BMR.

Table 33 Lemon, 1977. Energy cost of fire fighting³⁶

Activities	Energy cost of activity (kcal min ⁻¹)		PAR	
	Men	Women	Men	Women
Ariel LD climb	11–12.2		8.89	
Rescue victim	12.7		9.67	
Dragging hose	12.7		9.79	
Ladder raise	11.5		8.76	

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio. Subjects: 20 male professional firefighters, anthropometric profiles for each activity provided by the authors. Measurement: expired gas volumes collected and aliquots measured using a Gallenkamp–lloyd Gas analyser. Each activity was on ? five subjects repeated on two separate occasions. PAR based on predicted BMR.

Table 34 Li Jing, 1991. Energy cost of 'college activities'³⁷

Activities	Energy cost of activity (kcal m ² min ⁻¹)		PAR	
	Men	Women	Men	Women
Reading in bed	0.813	0.801	1.22	1.22
Sitting and thinking	0.839	0.818	1.25	1.25
Standing silently	0.886	0.846	1.32	1.29
Self-study	0.906	0.904	1.35	1.38
Watch TV	1.100	1.129	1.64	1.72
Listen to music	0.970	0.939	1.45	1.43
Painting	0.838	0.835	1.25	1.27
Play musical instruments	1.346		2.01	
Play chess	0.930	1.006	1.39	1.53
Play cards	1.219	1.315	1.82	2.0
Watching a laboratory experiment	0.890	0.850	1.33	1.3
Carrying on animal experiment	1.262	1.382	1.88	2.11
Listening to lecture	1.146	1.068	1.71	1.63
Leisure time				
Walking	2.608	2.561	3.9	3.9
Riding on bicycle	2.542	2.372	3.62	3.62
Exercising on horizontal bar	3.490	3.426	5.22	5.22
Long distance running	3.202	2.666	4.79	4.06
Dancing fast	4.221	4.293	6.31	6.54
Dancing moderate	3.640	3.463	5.44	5.28
Dancing slowly	2.199	2.266	3.29	3.45
Tennis	3.905	3.884	5.84	5.92
Volleyball	4.054	3.977	6.06	6.06
Basket ball	4.652	5.078	6.95	7.74
Football	5.671		8.48	
Sprint	5.490	5.433	8.21	8.28
Push-up	3.490	3.426	5.22	5.22
Sewing		1.188		1.81
Skill gym		3.210		4.89
Middle distance running		4.010		6.11

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio.
 Subjects: numbers for each activity not given – 606 subjects randomly selected from Shanghai Medical University (319 males, 287 females, age range 18–24 years, no anthropometry available).
 Measurements: Douglas bag with volume, and gas measurements – S-3A O₂, H&B CO₂.
 PAR is what has been provided in the text.

Table 35 Littell, 1969. Energy costs of flying³⁸

Activities	Energy cost of activity (kcal min ⁻¹)		PAR	
	Men	Women	Men	Women
Light helicopter				
BMR <i>n</i> = 8	1.18			
Sitting (5 min)	1.74			1.47
Hover/Taxi (4 min)	2.17			1.84
Ascend (2 min)	2.06			1.75
Level 1 (5 min)	1.60			1.36
Aerobatics (7 min)	1.61			1.36
Level 2 (5 min)	1.50			1.27
Descend (2 min)	1.75			1.48
Utility helicopter				
Basal (BMR) <i>n</i> = 8	1.19			
Sitting (5 min)	1.60			1.34
Hover/taxi (4 min)	1.76			1.48
Ascend (2 min)	1.69			1.42
Level 1 (5 min)	1.58			1.32
Aerobatics (7 min)	1.54			1.29
Level 2 (5 min)	1.42			1.19
Descend (2 min)	1.52			1.28
Medium helicopter				
Basal (BMR) <i>n</i> = 7	1.21			
Sitting (5 min)	1.60			1.32
Hover/taxi (4 min)	2.03			1.68
Ascend (2 min)	2.03			1.68
Level 1 (5 min)	1.71			1.41
Aerobatics (7 min)	1.73			1.43
Level 2 (5 min)	1.67			1.38
Descend (2 min)	1.85			1.53
Fixed wing utility aircraft				
BMR <i>n</i> = 4	1.04			
Sitting (5 min)	1.72			1.65
Hover/taxi (4 min)	2.69			2.58
Ascend (2 min)	2.78			2.67
Level 1 (5 min)	1.87			1.8
Aerobatics (7 min)	1.76			1.69
Level 2 (5 min)	1.70			1.63
Descend (2 min)	2.43			2.34

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio.
 Subjects: 16 experienced aviators (age 39.5 years, height 176.1 cm, weight 78.7 kg, all mean).
 Equipment: expired air collected through a facemask, connected to a Mueller Franz gas meter for volume and a paramagnetic O₂ analyser (Beckman model E-2).
 PAR calculated using measured BMR.

Table 36 Louhevaara, 1988. Sorting of postal parcels, in a simulated work place³⁹

Activities	Energy cost of activity (VO ₂ litre min ⁻¹)		PAR	
	Men	Women	Men	Women
Slow sorting (4 min at each level of activity) 3 parcels per minute, walking speed 0.3 m s ⁻¹ . (Wt of parcels 15.3 kg min ⁻¹)	1.03			4.09
Habitual sorting (8.6 parcels per minute, 0.6 m s ⁻¹ 43.9 kg min ⁻¹)	1.36			5.4
Accelerated sorting (10.8 parcels per minute, 0.7 m s ⁻¹ 55.1 kg min ⁻¹)	1.80			7.14
Maximal sorting (16.9 parcels per minute, 1.0 m s ⁻¹ , 86.2 kg min ⁻¹)	2.18			8.65

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio.
 Subjects: 21 healthy male sorters of postal parcels (age 33.3 years, height 178.4 cm, weight 78.3 kg, per cent fat 18.4).
 Equipment: microprocessor controlled respiratory gas analyser (Morgan 500d), using a paramagnetic O₂, and infrared CO₂ analyser.
 Measurement: 100 parcels of standard weight had to be sorted and placed in two trolleys based on postal code.
 PAR based on predicted BMR.

Table 37 Malhotra, 1976. Energy cost of a variety of activities in Indian submariners⁴⁰

Activities	Energy cost of activity (kJ min ⁻¹)		PAR	
	Men	Women	Men	Women
Sleep	4.35		0.94	
Rest and relaxation	4.85		1.04	
Reading and writing	5.02		1.08	
Standing	5.31		1.15	
Eating and drinking	6.27		1.35	
Equipment operation, action station, on duty, watch keeping	8.28		1.79	
Toilet and dressing	8.36		1.81	
Equipment cleaning	12.12		2.62	
Ascending and descending ladders	16.01		3.46	
Walking between compartments	16.55		3.58	
Loading and unloading	16.55		4.35	
Clean ship: done at surface	24.66		5.33	

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio. Subjects: numbers uncertain (age 26 years, weight 59.8 kg, height 168.8 cm). Equipment: Kofranyi–Michaelis respirometers with Scholander micro-gas analysers. Measurements: done at 'steady state'. PAR based on predicted BMR.

Table 38 Marchetti, 1980. Energy cost of sailing⁴¹

Activities	Energy cost of activity (VO ₂ in ml min ⁻¹)		PAR	
	Men	Women	Men	Women
Energy cost of sailing	340	283	1.42	1.54
	340		1.42	

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio. Subjects: Three Caucasian subjects: two male and one female (individual anthropometric details given in the paper). Equipment: Douglas bags and Haldane–Margaria gas analyser. Measurement: use of trapeze which allows subject to extend body out-board. Only data on the 'lake' are used here. Simulated lab conditions not used. VO₂ collected for 5 minutes at steady state, 5 minutes after start of routine. PAR calculated based on predicted BMRs.

Table 39 Montgomery, 1977. Energy costs of activities of Amazon Indian hunter-gatherer-horticulturalists⁴²

Activities	n	Energy cost of activity (kcal min ⁻¹)		PAR	
		Men	Women	Men	Women
Walking open foot paths	6	5.3		5.1	
Walking level forest paths	6	6.0		5.78	
Walking up forest paths	9	8.9		8.57	
Walking down forest paths	3	4.1		3.95	
Clearing undergrowth	5	7.3		7.03	
Felling large trees	8	7.6		7.32	
Planting maize	2	4.3		4.14	
Planting manioc	7	5.2		5.01	
Weeding slope	4	6.1		5.87	
Cutting grass	1	7.0		6.74	
Harvesting maize	5	5.3		5.1	
Harvesting manioc	4	4.4		4.24	
Removing palmheart	1	6.2		5.97	
Chopping firewood logs	2	6.7		6.45	
Net bag manufacture	9	2.6		2.5	
Cane box manufacture	2	2.2		2.12	
Bow and arrow manufacture	15	2.7		2.6	
Planting root crops	2		2.9		3.69
Harvesting root crops	7		2.7		3.43
Catching fish with hands	4		3.1		3.94
Weeding yard	2		2.4		3.05
Sweeping yard	1		2.8		3.56
Deseeding cotton	2		1.4		1.78
Beating cotton	4		1.9		2.42
Spinning cotton	6		1.1		1.4
Setting loom	2		2.0		2.54
Weaving	8		1.8		2.29
Grinding maize	6		2.8		3.56
Peeling manioc	3		2.1		2.67
Splitting manioc	2		2.0		2.54
Straining manioc	6		1.9		2.42
Washing laundry	3		2.6		3.31

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio. Subjects: Eight men (age 25 years, weight 51.8 kg) and eight women (age 25 years, weight 44.5 kg, all means). Variable numbers for different studies. Equipment: Max Planck respirometer with a fuel cell powered Teledyne oxygen analyser. PAR based on predicted BMR.

Table 40 Nag, 1980. Various agricultural tasks in India⁴³

Activities	Energy cost of activity (kJ min ⁻¹)		PAR	
	Men	Women	Men	Women
Seeding operations				
Sitting, resting	4.25/0.86		1.01	
Free walking on plane surface	11.21/1.06		2.68	
Free walking on puddle field	13.73/0.53		3.28	
Transplanting, bending on puddle field	13.01/0.93		3.1	
Germinating seeder	34.42/2.34		8.21	
Germinating seeder (IRRI type) The IRRI seeder consists of eight concentric aluminium pipes running upwards to a hopper, i.e. the germinating seed reservoir. The distance between the pipes at the ground level is about 20 cm. As the structure is pulled manually on a chain wheel a flap of the reservoir is opened to the pipes through which seeds come out and fall on the ground	40.2/3.64		9.59	
Threshing operation				
Manual threshing by beating	19.26/1.18		4.6	
Pedal threshing	27.56/3.25		6.58	
Pedal threshing, helper	13.53/1.99		3.23	

Abbreviations: BMR – basal metabolic rate; IRRI – International Rice Research Institute; PAR – physical activity ratio. Five male agricultural workers (age 23.4, height 164.6 cm, weight 49.9 kg, all means). Equipment: KM respirometer linked to a Beckman paramagnetic O₂ analyser. At 'steady state' measurements were made. PAR calculated using predicted BMR.

Table 41 Nag, 1981. Variety of household and agricultural tasks⁴⁴

Activities	Energy cost of activity (kJ min ⁻¹)		PAR	
	Men	Women	Men	Women
Squatting on floor washing utensils		5.42		1.57
Kneeling down and working (e.g. sweeping floor)		7.89		2.29
Making bed at 20 inches height		11.7		3.41
Spreading grains/veg on the floor		15.05		4.36
Winnowing (sitting)		8.57		2.49
Walking		11.48		3.33
Weeding with sickle (sitting)		11.54		3.35
Uprooting (sitting)		11.96		3.47
Harvesting paddy field (sitting)		12.17		3.53
Transplanting paddy seedlings		12.33		3.575
Harvesting (bending)		12.78		3.71
Weeding using sickle (bending)		14.45		4.189
Uprooting (bending)		15.5		4.49
Digging dry soil using spade		19.5		5.65
Pounding (single woman)		21.74		6.3
Pounding (two women)		19.19		5.56

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio. Subjects: Indian females $n = 8$, (age 30.4 years, weight 41.2 kg, height 149.4 cm, all means). Equipment: open-circuit respirometer linked to paramagnetic O₂ analyser. PAL based on predicted BMR.

Table 42 Norgan, 1974. Large range of activities measured on 204 New Guinean adults living in two villages⁴⁵

Activities	n	Energy cost of activity (kcal min ⁻¹)		PAR	
		Men	Women	Men	Women
KAUL men					
Lying	42	1.14		1.05	
Sitting	41	1.23		1.13	
Standing	40	1.32		1.21	
All sitting					
Sitting weaving bamboo mat	1	1.4		1.29	
Sitting: tie morotta	1	1.5		1.38	
Separating copra and shell	1	1.8		1.66	
Sew morotta	2	1.9		1.75	
Carve plate, drum or comb	3	2.0		1.84	
Fish from canoe	2	2.1		1.94	
Weave bamboo wall	2	2.8		2.58	
Cut copra	1	3.1		2.86	
Paddle canoe	2	3.3		3.04	
All standing					
Clean gun	1	1.6		1.47	
Mend lamp	1	1.9		1.75	
Fish with line	1	2.0		1.84	
Tie fence	1	2.0		1.84	
Plant tobacco	1	2.3		2.12	
Chop firewood	1	2.5		2.3	
Fish with spear	1	2.5		2.3	
Work in store	1	2.6		2.4	
Prune cocoa	1	2.6		2.4	
Cut tobacco	1	2.7		2.49	
Clear light bush	4	2.8		2.58	
Disbud tobacco	1	2.9		2.67	
Weed with shovel or hoe	2	3.1		2.86	
At 'sing-sing'	1	3.1		2.86	
Make fence	1	3.5		3.23	
Collect Daka (piper)	1	3.6		3.32	
Cycling	1	4.5		4.15	
Cut saplings	3	4.0		3.69	
Walking	37	4.2		3.87	
Walking slowly	17	3.3		3.04	
Walking around	15	2.4		2.21	
Weeding	4	2.7		2.49	
Clean garden	2	3.1		2.86	
Cut grass	17	5.7		5.25	
Collecting coconuts	2	4.5		4.15	
Husking coconuts	4	6.1		5.62	
Bag coconuts	3	3.9		3.59	
Bag and split coconut	6	4.2		3.87	
Hunting flying fox	2	3.2		2.95	
Hunting pigs	2	3.5		3.23	
House building					
Cut bamboo	1	3.1		2.86	
Cut limbom trunks	2	4.0		3.69	
Collect bom bom	1	4.0		3.69	
Dig post-holes	1	6.0		5.53	
Lay floor	1	4.0		3.69	
Nailing	1	3.2		2.95	
KAUL women					
Lying	41		1.03		1.19
Sitting	41		1.08		1.25
Standing	41		1.19		1.38
Sitting or squatting activities					
Sewing	2		1.2		1.39
Prepare tobacco	3		1.3		1.50
Remove beans	2		1.3		1.50
Split cocoa	1		1.7		1.97
Break galips	4		1.6		1.85
Squeeze coconut	2		2.1		2.43
Weaving bilum	6		1.2		1.39
Preparing rope	6		1.3		1.5

Table 42 Continued

Activities	n	Energy cost of activity (kcal min ⁻¹)		PAR	
		Men	Women	Men	Women
Peeling taro	33		1.5		1.73
Standing activities					
Collect tulip leaves	1		1.6		1.85
Put on rope	1		2.0		2.31
Cut tobacco	3		2.1		2.43
Sweeping	7		2.2		2.54
Wash clothes	3		2.4		2.77
Disbud tobacco	2		2.4		2.77
Collect cocoa	1		2.5		2.89
Cut weeds, sarif	1		2.6		3.01
Collect leaves along the path	1		2.6		3.01
Dig holes for planting	2		3.7		4.28
Catch crabs	1		3.9		4.51
Walking	26		3.5		4.05
Walking slowly	10		2.6		3.01
Walking around	16		1.8		2.08
Walking with load	19		3.4		3.93
Weeding	12		2.3		2.66
Clean garden	4		3.5		4.05
Plant taro	6		3.1		3.58
Dig taro	10		2.6		3.01
Cut grass	5		4.3		4.97
LUFA men					
Lying	34	1.28			1.18
Sitting	34	1.6			1.48
Standing	32	1.47			1.36
Sitting activities					
Make arrows	5	1.8			1.66
Play 'matches'/cards	3	1.5			1.39
Weave pitpit wall	2	1.9			1.75
Unload mumu stone	1				1.66
Sharpen axe	1				1.66
Prepare food (peel tubers)	1	1.4			1.29
String loom	1	2.0			1.85
Standing activities					
Pick coffee	10	2.6			2.4
Chop firewood	7	5.0			4.6
Collect bush rope	1	4.2			3.88
Play football in village	1	3.3			3.05
Walking	7	4.2			3.88
Walking slowly	1	3.1			2.86
Walking uphill slowly	2	5.0			4.62
Walking uphill average	19	6.0			5.54
Walking uphill fast	5	7.9			7.29
Walking downhill slowly	3	3.0			2.77
Walking downhill average	18	3.3			3.05
Walking downhill fast	3	3.8			3.51
Walking with load uphill	3	7.1			6.56
Clearing ground	6	4.9			4.52
Dig ground	4	5.9			5.45
Cut pitpit	1	3.1			2.86
Cut tree	1	5.8			5.36
Split wood for posts	5	4.4			4.06
Sharpen posts	2	4.2			3.88
Put in fence posts	3	4.6			4.25
Tie fence posts	4	3.3			3.05
Shovelling road work	1	5.0			4.62
Dig barat	1	6.5			6.0
Tie sugar cane	2	3.2			2.95
Tie banana stem	2	3.5			3.23
Clean garden	6	4.9			4.52
Weeding	5	2.6			2.4
Hunting birds	1	3.6			3.32
Pull kunai grass	1	2.7			2.49
Roof house	1	3.1			2.86

Table 42 Continued

Activities	n	Energy cost of activity (kcal min ⁻¹)		PAR	
		Men	Women	Men	Women
LUFA women					
Lying	31		1.11		1.32
Sitting	29		1.21		1.43
Standing	30		1.29		1.53
Sitting or squatting activities					
Sew clothes	1		1.3		1.54
Skin coffee	3		1.4		1.66
Sew pandanus mat	2		1.4		1.66
Load mumu with food	1		2.4		2.85
Preparing rope	9		1.3		1.54
Weaving bilum	1		1.4		1.66
Peeling sweet potato	7		1.3		1.54
Roasting corn	1		1.2		1.42
Walking	3		3.3		3.91
Walking around	2		2.4		2.85
Walking with load	1		7.0		8.3
Walking uphill slowly	1		3.6		4.27
Walking uphill average	17		5.1		6.05
Walking uphill fast	2		6.0		7.12
Walking downhill slowly	4		2.1		2.49
Walking downhill average	13		2.7		3.2
Walking downhill fast	5		3.1		3.68
Walking with load uphill	10		5.5		6.52
Walking with load downhill	1		4.2		4.98
Clearing ground	6		3.3		3.91
Dig ground	9		4.2		4.98
Weeding	8		2.6		3.08
Plant sweet potato	3		4.2		4.98
Collect sweet potato	9		2.7		3.2
Pick coffee	10		3.1		3.68

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio. Subjects: KAUL: 51 males (age 34 years, weight 56 kg, height 160 cm, per cent fat 10%) 69 females (age 31 years, weight 47.3 kg, height 151 cm, per cent fat 22%). LUFA: 43 males (age 28 years, height 159 cm, weight 57.5 kg, per cent fat 10%) Women (age 25 years, height 152 cm, weight 50.9 kg, per cent fat 22%). Equipment: lying down and sitting activities measured using Douglas bag and Lloyd Haldane apparatus for O₂ and CO₂. For other activities – Max Planck respirometer was used. PAR calculated from predicted BMR.

Table 43 Oberoi, 1983. Manual and machine washing of clothes⁴⁶

Activities	n	Energy cost of activity (kcal m ² min ⁻¹)		PAR	
		Men	Women	Men	Women
Squatting on the ground			1.72		3.0
Sitting on patra (6.5 cm stool)			1.14		1.99
Sitting on pihri (13 cm)			1.56		2.7
Standing at sink			1.15		2.0
Machine wash (part manual)			1.10		1.92

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio. Subjects: Indian female college students, n = 15 (age 20.7 years, weight 48.5 kg, height 155.3 cm, all means). Measurements: expired gas in Douglas bag – Orset volumetric O₂. PAR based on predicted BMR.

Table 44 O'Connell, 1986. Energy cost of simulated stair case climbing for firemen (fully geared)⁴⁷

Activities	n	Energy cost of activity (VO ₂ in litre min ⁻¹)		PAR	
		Men	Women	Men	Women
Staircase climbing with turnouts, boots, breathing apparatus, and 50 ft, 11/2 'canvas hose with nozzle and coupling on shoulder' (wt = 86.5 lb)			3.15 ± 0.28 mean ± SD VO ₂		12.22

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio. Subjects: 17 firefighters, all male (age 32.3 years, height 182.1 cm, weight 82 kg, per cent fat 15.3). Equipment: breathing apparatus linked to Beckman O₂ analyser (OM-11). PAR based on predicted BMR.

Table 45 Pal, 1994. Energy cost of mining activities in India⁴⁸

Activities	n	Energy cost of activity (kJ min ⁻¹)		PAR	
		Men	Women	Men	Women
Drilling with jackhammer					
Tunnel face	9	16.76		3.55	
Post and pillar	10	14.87		3.15	
Horizontal cut and fill	7	19.69		4.17	
Room and pillar	4	22.84		4.84	
Timbering/grouting					
Timbering/preparing face	5	18.22		3.97	
Grouting operation	7	19.06		4.15	
Loading operation 1					
Cavo loader	12	17.18		3.67	
Eimco loader	12	18.65		3.99	
Loading operation 2					
LHD Operator	4	9.43		2.04	
Manual mining					
Shovelling job	10	21.37		4.59	

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio. Subjects: 54 male miners. Variable numbers for each activity. Anthropometric characteristics of each subset of subjects provided by the authors. Equipment: Oxylog, O₂ converted to energy using 21 kJ per litre. Measurements: carried at between 28°C and 32°C and humidity between 50% and 99%. PAR based on predicted BMR.

Table 46 Phillips, 1954. Energy cost of common West African agricultural activities⁴⁹

Activities	n	Energy cost of activity (kcal min ⁻¹)		PAR	
		Men	Women	Men	Women
Grass cutting: cut as in a sickle with body bent at the waist and head down	6	4.48		4.26	
Bush clearing: using a machete, 18 inches long and 2 inches wide	6	6.2		5.89	
Hoeing: short spade – for earthing up root crops and weeding and clearing small root stumps	6	4.57		4.34	
Load carrying using a shallow basin on the head (2 ft in diameter and 6 inches deep). Brick, rubble and cement is often transported like this					
Head planning (20 kg)	6	3.63		3.45	
Head planning (30 kg)	6	4.42		4.2	
Head planning (35 kg)	5	5.25		4.99	
Log carrying (20 kg): on the head with one hand up to steady the log	6	3.55		3.37	
Tree felling	5	8.4		7.98	
Sawing: sawing is away from the body with the blade held in a vertical position	5	6.0		5.7	
Walking	6	3.06		2.91	
Sitting	7	1.3		1.24	
Standing	6	1.3		1.24	

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio.
 Subjects: Seven Nigerian males. Variable numbers for different activities (age 28.6 years, weight 54.7 kg, height 163.4 cm, all means).
 Equipment: Douglas bag of 500 l capacity linked to Haldane apparatus.
 Measurements: at least two per subject per activity at intervals of 2–3 weeks.
 PAR based on predicted BMR.

Table 47 Ramana Murthy, 1966. Energy cost of agricultural activities in India⁵⁰

Activities	n	Energy cost of activity (kcal min ⁻¹)		PAR	
		Men	Women	Men	Women
Ploughing	11	5.48		5.79	
Puddling	11	6.45		6.75	
Working push hoe	12	4.66		4.87	
Trimming bunds	10	6.28		6.73	
Making channels for irrigation	6	3.25		3.53	
Harvesting	10	3.8		4.08	
Making of bundles	9	3.48		3.68	
Threshing	9	5.27		5.56	

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio.
 Subjects: 30 male labourers who had worked for at least 5 years, variable numbers for each activity. Authors provide anthropometry of each data subset.
 Equipment: Kofranyi–Michaelis calorimeter. Gas analysis using a portable Haldane gas analysis apparatus.
 PAR calculated using predicted BMR.

Table 48 Raven, 1973. Energy cost of specific tasks of aluminium smelter workers in Tennessee⁵¹

Activities	Energy cost of activity (kcal min ⁻¹)		PAR	
	Men	Women	Men	Women
Subject 1				
Sitting	1.85		1.48	
Using automatic crowbar on 1 pot	4.23		3.38	
Oreing pot	3.75		3.0	
Subject 2				
Sitting	1.35		1.05	
Using automatic CB on front of pot	3.05		2.38	
Using CB at front of pot for 2 pots	3.1		2.42	
Walking sweeping and oreing 2 pots	3.75		2.93	
On CB for 1 pot	3.15		2.46	
Subject 3				
Sitting	2.1		1.63	
Break crust with hand jack hammer	5.6		4.34	
Move cradle for carrying hand jackhammer next to pot and break crust	4.2		3.26	
Subject 9				
Break crust with jackhammer	6.95		5.43	
Remove cover over pots	7.1		5.54	
Unhook and hook carbons	3.5		2.73	
Loosen carbon with pneumatic wrench	5.15		4.02	
Placing carbon into position	4.55		3.55	
Set carbon and tighten clamps	3.75		2.93	
Recovery of molten metal	4.85		3.79	
Moving siphon	6.25		4.88	
Subject 8				
Sitting	1.75		1.4	
Walking	2.75		2.21	
Rowelling pot	5.4		4.33	
Subject 7				
Sitting	1.35		1.07	
Using jackhammer with extension to clean crucible	5.53		4.39	
Jackhammer mainly held overhead and at chest height	4.43		3.52	
Using jackhammer overhead resting on crowbar support	6.35		5.05	
Subject 10				
Cleaned 1–½ Butts using jackhammer	6.45		4.92	
Subject 11				
Potman riding tricycle across ½ the pot line (½ a room)	3.25		2.42	

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio.

Subjects: Eight subjects – details of age and anthropometry for each subject provided by the authors.

Measurements: 'Spot collection' of expired gases, using a light-weight gas collection system with a manually operated valve linked to Beckman C2 O₂ analyser and CO₂ absorber. VO₂ was recomputed to provide kcal min⁻¹.

The jobs ranged from sweeping and light raking of bauxite ore across the pot surface to the wielding of a 14 lb sledgehammer to break up the remnants of a carbon anode into pieces. Generally, hand held jackhammers were used to break the surface crust that was formed on the molten metal during the reduction process. Molten metal was siphoned under vacuum from the reduction pot into a large cylindrical cradle, which was manoeuvred from place to place by an overhead crane. Anodes (carbons) were moved into position by the crane after being hooked to the winch by the worker. Final positioning of the anode within the pot was accomplished by the worker using a crowbar. The collecting cradle was cleaned by breaking the remaining slag from the sides and bottom of the container with a hand-held jackhammer.

PAR based on predicted BMR. Data provided for each subject separately.

Table 49 Samata A, 1981. Energy cost of manual lifting of loads by Indians⁵²

Activities	Energy cost of activity (kJ min ⁻¹)		PAR	
	Men	Women	Men	Women
Load 9 kg, rate 9 per min, ht 1.55 m	24.78/3.42		5.78	
Load 16.3 kg, rate 9 per min, ht 1.55 m	41.37/4.59		9.65	

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio.

Subjects: *n* = 21 ? males (age 29.3 years, weight 52.1 kg, height 166 cm, all means).

Equipment: Douglas bag with Haldane Gas analysis apparatus.

Measurements: collection of expired air 10 minutes after start of task.

PAR based on predicted BMR.

Table 50 Samanta, 1987. Load (head) carrying by physically active, healthy, Indian porters⁵³

Activities	Energy cost of activity (kJ min ⁻¹)		PAR	
	Men	Women	Men	Women
Load (kg)				
0	9.67/0.86		2.26	
20	14.61/1.47		3.42	
30	17.9/1.58		4.18	
40	21.6/2.15		5.05	
50	26.1/2.71		6.1	
60	30.0/3.83		7.01	

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio.
 Subjects: Five male subjects (20–29 years, weight 51.8 kg, height 160.2 cm).
 Equipment: Douglas bag with Haldane Gas analysis.
 Measurements: for 10 minutes, speed of walking = 5 km h⁻¹.
 PAR based on predicted BMR.

Table 51 Schmidt, 1985. Energy cost of kendo (traditional Japanese fencing)⁵⁴

Activities	Energy cost of activity (kcal min ⁻¹)		PAR	
	Men	Women	Men	Women
5 min Kendo bout wearing full armour	15.64		12.97	

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio.
 Subjects: Eight adult trained (>5 years), male, Caucasian kendokas (age 28.4 years, height 176.8 cm, weight 69.3 kg, per cent fat 14.4%).
 Equipment: open-circuit gas analysis – Parkinson-Cowan dry gas meter and a Beckman gas analyser.
 PAR calculated from predicted BMR.

Table 52 Sheldahl, 1992. The energy cost of shovelling snow⁵⁵

Activities	Energy cost of activity (VO ₂ – ml kg ⁻¹ min ⁻¹)		PAR	
	Men	Women	Men	Women
Self-paced lift-throw	25.2		8.08	
Self-paced push-throw	24.4		7.82	
Paced lift-throw	24.0		7.7	

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio.
 Subjects: 12 younger normal men (age 40 years, weight 81 kg, all means).
 Equipment and measurement: open-circuit spirometry. VO₂ determined at 6 minutes and 8 minutes of each procedure.
 Analysis of O₂ done within 5 minutes of collection. Snow depth of 3–4 inches
 PAR calculated from predicted BMR.

Table 53 Spurr, 1975. Energy cost of cutting sugar cane⁵⁶

Activities	Energy cost of activity (VO ₂ – litre min ⁻¹)		PAR	
	Men	Women	Men	Women
am				
Rest-sitting position	0.25		1.15	
5–10 min after starting sugar cane cutting	1.50		6.88	
20–25 min after starting cutting sugar cane	1.46		6.7	
pm				
Rest-sitting position	0.25		1.15	
5–10 min after starting sugar cane cutting	1.51		6.9	
20–25 min after starting cutting sugar cane	1.44		6.6	

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio.
 Subjects: 61 ? males who were experienced sugar cane cutters (age 29.8 years, height 163.3 cm, weight 58.6 kg, per cent fat 10.3%, all means).
 Equipment: Kofranyi–Michaelis respirometer. Expired air analysed using gas chromatography.
 PAR calculated from predicted BMR.

Table 54 Spurr, 1977. Loading sugar cane on to wagons by picking cane singly or in bundles (1–2 kg) and throwing them onto the wagon⁵⁷

Activities	Energy cost of activity (VO ₂ – litre min ⁻¹)		PAR	
	Men	Women	Men	Women
Rest for 10 min prior to loading	0.25		1.12	
Loading	1.25		5.6	

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio. Subjects: 28 men employed as loaders (age 34 years, height 165 cm, weight 60.3 kg, per cent fat 9.9%, all mean). Equipment/measurements: Kofranyi–Michaelis respirometer – gas concentrations in expired air using gas chromatography. Measurements made in 3, 5 minute periods (10–15, 25–30 and 40–45 minutes after starting work). PAR from predicted BMR.

Table 55 Thornton, 1984. Energy cost of helicopter pilots flying two different types of helicopters⁵⁸

Activities	Energy cost of activity (watts)		PAR	
	Men	Women	Men	Women
Gazelle (light observation helicopter)				
Hover <i>n</i> = 6	145		1.67	
Level flight (1000 ft)	128		1.47	
Puma (medium battlefield support helicopter)				
Hover <i>n</i> = 3	232		2.59	
Level flight (1000 ft) <i>n</i> = 6	197		2.19	

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio. Subjects: 12 trained male defence pilots, under peace-time conditions, divided into two groups. Anthropometry details provided in the paper. Equipment: Oxylog. PAR calculated using predicted BMR.

Table 56 Tin-May-Than, 1988. Energy cost of weaving and domestic chores in Burmese⁵⁹

Activities	<i>n</i>	Energy cost of activity (kcal min ⁻¹)		PAR	
		Men	Women	Men	Women
Weaving	19		2.59		3.19
Spinning (sitting)	2		1.91		2.29
Spinning (standing)	1		1.52		1.89
Picking thread (sitting)	3		1.32		1.662
'Making paste' Burmese makeup	6		2.35		2.94
Washing clothes	2		2.2		2.5
Sitting (leisure)	15		1.14		1.4
Walking	18		2.22		2.75

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio. Subjects: *n* = 22. Variable numbers for different activities (age 19–43 years, height 150.8 cm, weight 45.9 kg, per cent fat 25.8, all means). Measurements: Douglas bag collections, volume and expired gas analysis. PAR based on predicted BMR.

Table 57 Torun, 1982. Energy costs of agricultural and domestic chores⁶⁰

Activities	<i>n</i>	Energy cost of activity (kcal min ⁻¹)		PAR	
		Men	Women	Men	Women
Lying down	23		1.14		1.3
Standing	8		1.15		1.31
Sitting/sewing	20		1.2		1.36
Ironing clothes	1		1.44		1.66
Picking coffee	6		1.5		1.7
Winnowing or dekernelising corn	15		1.63		1.85
Washing dishes	1		1.68		1.91
Cooking	19		1.75		1.99
Making Tortillas	48		2.08		2.36
House cleaning	16		2.2		2.5
Child care	4		2.22		2.52
Washing clothes	16		2.69		3.06
Walking on a flat terrain without a load	31		2.73		3.1
Walking on a flat terrain carrying 5 kg			2.98		3.39
Walking on a flat terrain carrying 10 kg			3.22		3.65
Sweeping	33		3.12		3.55
Cutting fruit with a pole	1		3.34		3.8
Gleaning	5		3.95		4.49
Lifting and moving objects	4		4.04		4.59
Walking uphill	18		4.25		4.83
Chopping wood			4.32		4.91
Carrying a 10 kg load uphill	24		5.77		6.56

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio. Subjects: *n* = 58, Guatemalan rural women, 12 in 2nd or 3rd trimester, 30 lactating (age 27 years, weight 49.1 kg, height 150 cm, all means). Equipment: Kofranyi–Michaelis initially, but most with Douglas bag and subsequent calibrated analysis. Measurements: collections were for 2–5 minutes, starting after 2 minutes for light tasks and 3–5 minutes for heavy tasks. PAR calculated using predicted BMR.

Table 58 Town, 1980. Energy cost of rope skipping in both men and women⁶¹

Activities	<i>n</i>	Energy cost of activity (kcal min ⁻¹)		PAR	
		Men	Women	Men	Women
125 skips per min	15.7	10.9	12.5	12.27	
135 skips per min	16.0	11.1	12.75	12.49	
145 skips per min	16.5	10.9	13.15	12.26	

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio. Subjects: 11 females (age 21.8 years, weight 53.3 kg) and 19 males (24.7 years, weight 73.7 kg). Equipment: modified gas collecting system to allow skipping. Gas collected via tubing into meteorological balloons and analysed using Beckman E2 and LB1 analysers. Measurement: gas collection for 5 minute after start. PAR calculated using the predicted BMR.

Table 59 Viteri, 1971. Energy cost of common agricultural activities in Central America⁶²

Activities	n	Energy cost of activity (kcal min ⁻¹)		PAR	
		Men	Women	Men	Women
Sitting	19	1.21		1.08	
Standing	18	1.28		1.14	
Office work, wash stable with water hose	5	1.73		1.54	
Wire fence, sharpen tools, tie iron rods in construction work, drive truck or tractor, wash buckets	21	2.59		2.31	
Hackle barn floors, Open holes with a straight hoe, milk cows	19	3.44		3.07	
Walk with or without moderate load, drive cattle, shovel hay with a trident, ride horse, hand mix cattle feed	31	4.47		3.99	
Walk with a heavy load, Push a wheel barrow, Open ditch with a hoe, shovel sand, Mow with machete (standing), Cut wood with machete, cut wood with hand saw	40	5.6		5.0	
Distribute gravel with hoe, hand gather cut weeds, mow with scythe, mow with machete (leaning), open deep furrow with hoe or pick, hoe in water ditch	46	6.33		5.65	
Mow with sickle, shovel heavy material, harvest forages with machete	12	7.18		5.65	
Ride bicycle on farm roads	6	10.0		6.41	

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio.
 Subjects: 18 men (age 29.7 years, height 160.9 cm, weight 60.1 kg).
 Equipment: KM respirometer calib at 2-week intervals. Air analysed using the Scholander.
 Measurements: expired air collected for last 10 minutes of 15–20 minute activity period. Each activity measured in duplicate and the mean taken.
 BMR measured in 15 subjects.

Table 60 Wilke, 1995. Variety of household tasks⁶³

Activities	Energy cost of activity (VO ₂ –ml kg ⁻¹ min ⁻¹)		PAR	
	Men	Women	Men	Women
Vacuum carpet		10.7/0.9 SE		3.88
Mop floor		12.2/0.7 SE		4.43
Change bed		12.7/0.6 SE		4.61
Wash floor		13.7/0.8 SE		4.96

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio.
 Subjects: data presented here only for the normal controls, 10 Caucasian women (age 62 years, weight 64 kg).
 Measurements: min–max VO₂ measured by open-circuit spirometry. Each task 6–8 minute steady state expected to be achieved by 6 minutes PAR based on predicted BMR.

Table 61 Wilmore, 1978. Energy cost of circuit-training (three sets through a 10 station circuit)⁶⁴

Activities	Energy cost of activity (kcal min ⁻¹)		PAR	
	Men	Women	Men	Women
Energy cost of circuit training	9.0	6.1	6.96	6.29

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio.
 Subjects: 20 men (age 23.7 years, height 180.6 cm, weight 77.5 kg, per cent fat 14.3) and 20 women (age 20.3 years, height 165.4 cm, weight 61.0 kg, per cent fat 26.4). All subjects were familiar with the concept and most had been participating in a training programme.
 Equipment/measurement: Beckman metabolic measurement cart. Measurements at 45 second intervals for each station through three complete circuits.
 PAR calculated using predicted BMR.

Table 62 Zhuo, 1984. Energy cost of Tai-Chi Chuan exercise⁶⁵

Activities	Energy cost of activity (VO ₂ –litre min ⁻¹)		PAR	
	Men	Women	Men	Women
The long form of Yang's style with 108 successive movements in a set routine. Time req = 17.5–25 min (average 22 min)	1.03		4.19	

Abbreviations: BMR – basal metabolic rate; PAR – physical activity ratio.
 Subjects: 11 healthy males who had been practising Tai Chi regularly for 3–8 years (age 28.4 years, height 176.9 cm, weight 71.5 kg, per cent fat 13.9).
 Equipment: automated respiratory gas collection system (Jaeger Ergo-Oxyscreen) with paramagnetic and infrared analysers.
 PAR calculated using predicted BMR.

Table 63 Energy costs of a variety of activities abstracted from Passmore and Durnin, 1955². Different rows with similar activity identifiers indicate different studies

Activities	<i>n</i>	Energy cost (kcal min ⁻¹)	PAR
Personal necessities			
Males			
Washing hands and face and brushing hair	1	2.5	2.3
Washing and dressing	1	2.6	2.18
Dressing, washing and shaving	5	3.8	3.04
Dressing	9	4.0	3.32
Washing and shaving	4	2.6	2.3
Dressing	6	3.0	2.65
Females			
Washing, dressing and undressing	3	3.3	3.3
Light indoor recreation			
Males			
Sitting, listening to the radio	1	2.0	1.51
Sitting, listening to the radio	1	2.5	1.86
Sitting, writing	1	1.9	1.65
Sitting, writing	1	2.2	1.64
Sitting playing cards	1	1.9	1.44
Sitting playing cards	1	2.1	1.64
Sitting, playing accordion	1	2.2	1.84
Sitting, playing piano	1	2.5	2.25
Sitting, playing cello	1	2.6	2.28
Sitting, playing drums	1	4.0	3.71
Standing, drawing	1	2.3	2.0
Standing, conducting orchestra	1	2.5	2.22
Standing playing trumpet	1	2.1	1.77
Standing, playing double bass	1	2.5	2.49
Playing with children	3	3.5	3.11
Females			
Sitting, eating	1	1.5	1.55
Recreations involving moderate exercise (only males)			
Driving a car	3	2.8	2.43
Driving a motorcycle	3	3.4	2.95
Cycling (own pace)	10	8.2	6.8
Cycling (own pace)	1	5.9	5.48
Cycling (own pace)	1	6.6	5.62
Cycling (own pace)	1	10.3	8.63
Dancing, petronella	1	4.7	3.9
Dancing, foxtrot	1	5.2	3.93
Dancing, waltz	1	5.7	4.46
Dancing, rumba	1	7.0	5.81
Dancing, eightsome reel	3	7.7	5.97
Gardening, weeding	1	4.4	5.32
Gardening, weeding	1	5.6	4.94
Gardening, digging	1	8.6	7.69
Gymnastics-balancing exercises		2.5	2.09
Abdominal exercises		3.0	2.51
Trunk bending		3.5	2.93
Arms swinging, hopping		6.5	5.44
Bowls	1	4.4	3.74
Golf	1	5.0	4.38
Archery	2	5.2	4.69
Cricket, fielding	6	3.9	3.15
Cricket, bowling	6	5.2	4.21
Cricket, batting	6	6.0	4.85
Tennis	7	7.1	5.84
Recreations involving hard exercise			
Football, association		8.9	7.45
Sculling at 51 m min ⁻¹		4.1	3.5
Sculling at 69 m min ⁻¹		6.4	5.46
Sculling at 97 m min ⁻¹	11.2		9.55
Sculling at 61 per min		4.8	4.36
Sculling at 87 m min ⁻¹		7.0	6.35
Sculling at 93 m min ⁻¹		9.2	9.08
Sculling at 68 m min ⁻¹		5.5	5.34
Swimming, breast stroke	11.0		9.21
Swimming, back crawl	11.5		9.63
Playing squash racquets	10.2		8.62
Cross country running	10.6		9.12

Table 63 *Continued*

Activities	<i>n</i>	Energy cost (kcal min ⁻¹)	PAR
Domestic work			
Females			
Sewing, 30 stitches a min	2	1.14	1.33
Knitting, 23 stitches a min	2	1.17	1.37
Sweeping floors	4	1.7	1.99
Simple work, sitting		1.7	1.57
Washing small clothes		2.3	2.12
Stirring		3.0	2.77
Bringing in the wash		3.3	3.05
Polishing floor		4.8	4.43
Taking and hanging out the washing		5.0	4.62
Clearing floor, kneeling and bending		5.9	5.4
Scrubbing		7.0	6.46
Putting washing through mangle		8.0	7.39
Scrubbing, standing	3	2.9	3.35
Washing small clothes		3.0	3.1
Kneading dough		3.3	3.41
Wringing the wash by hand		4.4	4.54
Beating carpets and mats		4.9	5.06
Putting washing through a mangle (all)	1	6.0	6.2
Scrubbing, kneeling	3	3.4	
Scrubbing floors		3.6	3.4
Mopping		4.2	4.0
Taking out and hanging the wash		4.5	4.25
Bed making and bed stripping		5.4	5.1
Beating and brushing carpets (all)	1	7.8	7.37
Males			
Brushing boots		2.2	2.02
Cleaning windows (all)	1	3.0	2.76
Polishing	5	2.4	2.21
Peeling potatoes	1	2.9	2.4
Getting in coals		3.5	2.93
Breaking firewood (all)	1	4.9	4.1
Cleaning windows		3.7	3.3
Tidying beds (all)	10	3.9	3.48
Ironing	5	4.2	3.55
Energy cost of light occupational activities			
Shoemaker: fixing soles		2.4, 2.1	2.37
Filling soles		2.3	2.42
Polishing shoes (all)	1	1.8	1.9
Locksmith: filing with large file		3.3, 3.7	3.38
Five other processes (all)	1	2.1–2.9	2.42
Tailor: cutting		2.4	2.11
Machine sewing		2.8, 2.9	2.51
Hand sewing		1.9	1.67
Pressing (all)	1	3.5	3.08
Tailor: cutting		2.7	2.4
Machine sewing		2.6, 2.7	2.36
Hand sewing		2.0	1.78
Pressing		4.3	3.82
Energy cost of postmen climbing stairs at usual pace			
Load 11 kg		9.8	7.71
Load 16 kg		11.5	8.88
Load 16 kg		9.8	8.21
Load 16 kg (all)	1	13.8	10.7
Energy expenditure in the building industry			
Measuring wood		2.4	2.16
Machine sawing		2.4	2.16
Measuring and sawing		3.5	3.15
Joining floor boards		4.4	3.96
Miscellaneous work		4.5	4.05
Drilling hardwood		7.0	6.31
Chiselling		5.7	5.02
Sawing softwood		6.3	5.56
Sawing hardwood		7.5	6.61
Planing softwood		8.1	7.14
Planing hardwood		9.1	8.02

Table 63 *Continued*

Activities	<i>n</i>	Energy cost (kcal min ⁻¹)	PAR
Energy expenditure in agriculture, Russia 1933			
Males			
Ploughing	6.9		5.94
Thrashing rye	5.0		4.3
Ploughing	5.4		4.56
Thrashing rye	4.5		3.68
Females			
Binding oats	3.3		3.34
Binding rye	4.2		4.25
Binding oats	4.1		4.68
Binding rye	4.7		5.37
Weeding rape	3.3		3.77
Energy expenditure in agriculture, the Gambia, 1953			
Males			
Clearing shrub and dry grass	7.1		6.35
Ridging (deep digging)	9.5 (5.5–15.2)		8.88
Planting groundnuts	3.7 (3.1–4.5)		3.13
Weeding	5.3 (3.8–7.8)		4.65
Females			
Hoeing	5.8 (4.8–6.8)		6.48
Pounding rice	5.0 (3.9–6.4)		5.4
Energy expenditure in agriculture, Germany 1953			
Milking by hand	4.7		4.08
Machine milking 1 pail	3.4		2.95
Machine milking 2 pails	3.9		3.39
Cleaning milk pails	4.4		3.82
Horse ploughing	5.9		4.79
Horse ploughing (another kind of plough)	5.1		4.14
Tractor ploughing	4.2		3.41
Energy expenditure working with an axe			
Perpendicular blows			
Wt of axe 0.65 kg	11.4		8.49
Speed of blows 36 per min			
Wt 1.25	11.9		8.86
Speed 34 per min			
19	6.9		5.14
35	11.0		8.19
51	24.1		17.95
Wt 2.0	13.0		9.68
Speed 33 per min			
Horizontal blows			
Wt 0.65	12.0		8.94
Speed 34 per min			
Wt 1.25 kg	13.2		9.83
Speed 34 per min			
Wt 2.0	12.3		9.16
Speed 33 per min			
Energy expenditure of British soldiers			
Anti-gas drill	2.0		1.97
Weapon training	2.2		1.81
Kit inspection	2.3		1.83
Arms drill	2.4		2.01
Musketry	2.7		2.34
Polishing equipment	2.7		2.2
Mixed sports in the gym (incl rest pauses)	2.7		2.17
Cleaning kit and rifle	2.7		2.3
Throwing hand grenade	2.9		2.37
Guard and sentry drill	3.2		2.44
Company drill	3.4		3.13
Squad and platoon drill	3.7		3.07
Mixed sports outdoors (incl rest pauses)	3.8		3.21
Slow march	3.8		3.18
Marching (2 m h ⁻¹) with 27 kg load	3.9		3.27
Bayonet exercise	3.9		3.18
Physical exercises	4.1		3.43
Doing fatigues	4.1		3.29
Ironing equipment	4.2		3.55
Drill	5.0		4.11

Table 63 *Continued*

Activities	<i>n</i>	Energy cost (kcal min ⁻¹)	PAR
Marching (3 m h ⁻¹) with 27 kg load		5.3	4.44
Quick march		5.6	4.69
Field operation		5.9	4.58
Digging trenches		6.0	4.61
Obstacle course		6.2	4.97
Assault course		6.9	5.22
Marching (4 m h ⁻¹) with a 27 kg load		8.2	6.87
Rapid marching		9.7	8.12
Energy expenditure of British soldiers in India			
Standing at ease	10	1.3	1.16
Standing at attention		1.4	1.25
Cleaning equipment		2.9	2.59
Signalling with morse, semaphore and lamp		3.0	2.68
Musketry training		3.2	2.86
Musketry-firing on range		3.8	3.39
Sentry duty		3.5	3.13
Squad drill-without arms		4.7	4.2
Squad drill with arms		4.8	4.29
Throwing grenades		4.7	4.2
Marching in drill order (load 13 kg, speed 3.4 m h ⁻¹)		6.3	5.63
Bayonet exercises		6.7	5.98
Field exercises in extended order		7.8	7.0
Digging trenches		8.8	7.86
Horse clipping		4.2	3.61
Cleaning harness		4.8	4.13
Cleaning guns		5.1	4.39
Trotting on horseback		5.6	4.82
Cantering on horseback		6.4	5.51
Jumping on horseback		7.6	6.54
Harnessing and unharnessing		6.9	5.94
Grooming horses		8.3	7.14
Energy expenditure of US soldiers			
Inspection		2.4	2.34
Fatigue duties		2.4	2.34
Drill		3.8	3.7
Digging foxholes (mixed with marching and short rest periods)		4.6	4.48
Mass games		5.2	5.06
Field march		5.5	5.35
Field march with rifle		6.5	6.33
Obstacle course with pack and rifle		6.6	6.43
Creeping and crawling with full equipment		7.9	7.69
Field march with rifle and 27-lb pack at 3 m h ⁻¹		8.0	7.79
Field march with heavy pack		8.9	8.66
Energy expenditure of Yugoslav soldiers			
Dressing and undressing		2.5	2.11
Driving a tank		2.4	2.03
Adjusting caterpillar tracks		2.4	2.03
Cleaning a tank		2.8	2.37
Rifle exercises, lying down		2.8	2.37
Rifle exercises, kneeling		3.2	2.7
Taking off and putting on car tyres		3.3	2.78
Cleaning equipment		3.6	3.04
Cleaning gun		3.7	3.13
Rifle exercises, standing		3.8	3.21
Horse riding, slow		4.3	3.63
Cleaning horse		4.5	3.8
Lifting car by jack		4.5	3.8
Carrying boxes of ammunition		6.3	5.32
Horse riding, trotting		6.5	5.49
Digging a trench		8.0	6.76
Horse riding, galloping		8.1	6.84

Abbreviation: PAR – physical activity ratio.